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Children in a longitudinal high-risk infant follow-up program were evaluated at age 5 to determine whether they demonstrated behavior problems or cognitive deficits exceeding expectations based on conditions in their home environments. Normal expectations were determined through regression analyses on a group of age-matched controls. All high-risk subjects had been screened previously to exclude children with severe developmental disabilities. Although many high-risk children were found to be developing normally, substantial proportions showed significant behavioral and learning disabilities, even with adjustment for environmental conditions. While these outcomes were not related in any simple fashion to medical risk factors, complex statistical combinations of perinatal variables (generated through logistic regression) classified behavioral outcomes with a high degree of accuracy. (Author/RH)

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Environmental Influences and Perinatal Risk Factors in High Risk Children

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Running Head: ENVIRONMENTAL INFLUENCES

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Abstract

Children in a longitudinal high risk infant follow-up program were evaluated at age 5 to determine whether they demonstrated behavior problems or cognitive deficits exceeding expectations based on conditions in their home environments. Normal expectations were determined through regression analyses on a group of age-matched controls. All high risk children had been previously screened to exclude children with severe developmental disabilities. Although many high risk children were developing normally, substantial proportions showed significant behavioral and learning disabilities, even with adjustment for environmental conditions. These outcomes were not related in any simple fashion to medical risk factors, but complex statistical combinations of perinatal variables (through logistic regression) classified behavioral outcomes with a high degree of accuracy.

Key Words: High Risk
Behavior
Learning
Environmental Influences

Environmental Influences and Perinatal Risk Factors in High Risk Children

Within the past decade the survival rate for infants born with serious medical complications has increased significantly, with an associated increase in the number of children "at risk" for developmental disabilities and learning disorders. Even though the rate of major handicapping conditions (e.g., cerebral palsy, mental retardation) has remained stable (Stewart, Reynolds, & Lipscomb, 1981) many children are at increased risk for "high incidence-low severity" handicaps (Kopp & Krakow, 1983) that may have profound effects on learning progress or behavioral adjustment. Unfortunately, it has been very difficult to relate particular perinatal events to specific cognitive or behavioral outcomes at ages 2 to 5, and even combining obstetrical and perinatal variables into a "risk index" has not improved prediction significantly (Cohen & Parmelee, 1983; Minde et al., 1983; St. Clair, 1978).

This lack of clear relationships between early medical risk factors and later psychological functioning may reflect the inadequacy of current assessment procedures (McCall, Hogarty, and Hurlburt, 1972) or a failure to adequately account for environmental factors that are critical determinants of behavior (Sameroff, 1981). Environmental influences are of particular importance since predictive studies of preterm and low birth weight children have consistently found socioeconomic and social background factors to be superior to perinatal variables as predictors of later cognitive ability (Cohen & Parmelee, 1983; Siegel et al., 1982). Also,

there is evidence that significant biological risk may result in increased vulnerability to environmental stress (Escalona, 1982). It has even been suggested that the classic concept of a "continuum of reproductive casualty" (Pasamanick & Knobloch, 1961) should be reformulated as a "continuum of caretaking casualty" (Sameroff & Chandler, 1975) to reflect the importance of psychosocial factors and the limited accuracy of biomedical factors as predictors of later developmental status.

Although perinatal and psychosocial variables are simply combined in most predictive studies, this may maximize prediction but limit the ability to examine the nature of medical risk factors and their relation to developmental outcomes. It is obvious that the high risk child who is aggressive because his or her home environment promotes aggression is fundamentally different from the child who is aggressive despite a stable, supportive home environment, or that a slow learner from a family of college-educated professionals is considerably more "deviant" than a slow learner from a family of slow learners. If we want to investigate organic risk factors in high risk infants, then we must discriminate the child with "unexpected" developmental problems from the child whose behavioral difficulties are commensurate with familial and environmental expectations. Thus, to predict and understand children's behavior we need not only information about specific characteristics of the children, but also information about the environments in which these children function.

Although practical and objective measurement of environmental conditions is extremely difficult, several scales have recently been developed to assess dimensions of children's environments (Sines & Zimmerman, 1981).

These instruments are based on the assumption that quantifiable aspects of children's physical and psychosocial environments exert significant influences on health, cognitive development, and behavioral adjustment. A particularly promising scale that has been refined over the past several years is the Home Environment Questionnaire (HEQ) (Laing & Sines, 1982; Sines, 1983). The HEQ was designed to assess objective and verifiable characteristics of the home environment rather than more subjective parental perceptions (cf. Moos & Moos, 1976); therefore it includes questions about aspects such as physical characteristics of the home, life change events, parental absence, social habits, and educational backgrounds. Combinations of HEQ subscales have been shown to be highly related to significant child behavior problems such as aggression or social withdrawal (Laing & Sines, 1982). For the present study, the HEQ was selected as the primary measure of environmental conditions for a sample of high risk children.

The purpose of this study was to examine perinatal risk factors in high risk children whose behavioral and cognitive disabilities exceed expectations based on environmental factors. It was important to determine (a) whether 5-year-old high risk children have significantly more learning and behavior problems than their environments would typically produce and (b), if so, whether these problems relate to the early medical complications these children have experienced.

Method

Subjects

Subjects were recruited from an ongoing state-wide High Risk Infant Follow-up Program. This prospective longitudinal study represents a coordinated referral/treatment network involving the major population centers in the state. Over 1600 infants have been enrolled and evaluated since 1978. Infants are enrolled based upon any of the following criteria: Birthweight < 1500 grams; respiratory distress syndrome (documented by a specific diagnosis and differentiated from other signs of respiratory distress); bacterial meningitis (based upon bacteria in a CSF culture); asphyxia neonatorum (five minute Apgar ≤ 6); hypoglycemia (two consecutive blood glucose levels ≤ 40 mgm%); seizures (diagnosis confirmed by two physicians); hypotonia (documented by physician diagnosis); ventilatory assistance (for at least 2 hours); and other significant perinatal problems (e.g., hyperbilirubinemia, intrauterine growth retardation, severe psychosocial difficulties). Infants are routinely administered physical and developmental exams (including the Denver Developmental Screening Test) at 4, 9, 18, and 30 months of age. Those with significant health or developmental problems are referred for further evaluation by local educational agencies or a tertiary medical center.

In the summer of 1983, an investigation was begun with the first group of infants in the High Risk Infant Follow-up Program who were eligible for kindergarten entry in 1983. These 35 children had all passed the initial

phases of health and developmental screening (Denver Developmental Screening Test and physical examination) and had not exhibited general cognitive/developmental disabilities. The frequency of perinatal complications for these children is presented in Table 1.

Insert Table 1 about here

Sixty-five control subjects were obtained through a community school district and were drawn from the population of children who were routinely screened for developmental status as part of an annual "kindergarten round-up." All parents of control children completed a pre-evaluation questionnaire to eliminate children in this group who had experienced significant pre- or postnatal medical complications or developmental delays. Because only the oldest children in the High Risk program were of pre-kindergarten age at the time follow-up testing was initiated, the ages in the High Risk sample tended to be restricted to the narrow range of 57 to 62 months (mean = 59.5, SD = 1.3). However, the controls were selected to be representative of the entire pre-kindergarten population in the community with ages ranging from 58 to 72 months (mean = 64.4, SD = 3.8). (Adjustments for this small age difference were made in parts of the data analysis). The role of socioeconomic factors in perinatal risk has been well established (Kopp & Krakow, 1983), and it was not surprising that the High Risk children proved to have slightly lower levels of parental education than the normal controls (mean of 13.7 vs. 15.2 years). This further emphasized the need to adjust for home environment and family characteristics in determining behavioral outcomes (see Results) although the children in both groups came from predominately middle and upper middle class backgrounds.

Procedure

Evaluation was directed at determining the presence of specific learning and behavioral disorders in this population of high risk children. The children from the High Risk Program and the normal controls received extensive health, psychological, and psychosocial evaluations. A battery of cognitive and neuropsychological tests were used to assess language, perceptual-motor, conceptual, and memory skills. In addition, parents completed questionnaires regarding the child's development, behavior, and home environment. These included the Child Behavior Checklist (Achenbach & Edelbrock, 1983) and the Home Environment Questionnaire (Sines, 1983).

Throughout subject selection and evaluation, care was taken to provide appropriate safeguards for the welfare of the parents and children participating in the study. This included obtaining consent from the parents and maintaining the confidentiality of individual subject records.

Instruments

Behavioral Measures

Child Behavior Checklist (CBCL) (Achenbach & Edelbrock, 1983). This widely used behavior rating scale was completed by parents to obtain standardized information about the behavioral adjustment of the children in the study. The CBCL consists of 118 behavior problem items that are each scored on a three-point response scale. Parent ratings for each child were converted to normalized T-scores using the Revised Child Behavior Profile (CBP). The CBP derives scores on both narrow-band factors (e.g., Depressed, Social Withdrawal, or Aggressive) and broad-band factors (i.e., Internalizing and Externalizing). Analyses in the present study were restricted to scores on the more stable Internalizing and Externalizing

behavioral dimensions. Children with high Internalizing scores tend to "hold in" problems and are likely to be depressed, anxious, or withdrawn. Children with high Externalizing scores tend to "act out" feelings and are likely to be aggressive, hostile, or hyperactive.

Home Environment Questionnaire (HEQ) (Sines, 1983). This scale consists of a series of true-false questions to assess objectively verifiable characteristics of the home, neighborhood, and school environments. Separate forms of the scale were used for two-parent (HEQ-2R, 123 items) and single-parent (HEQ-1R, 91 items) families. Responses to the HEQ were converted to T-scores for each of 10 scales: Achievement, Aggression-External, Aggression-Home, Aggression-Total, Supervision, Change, Affiliation, Parent-Absence, Sociability, and Academic-Intellectual. More specific information about the development of preliminary forms of the scale is provided in Laing and Sines (1982).

Verbal Measures

A series of verbal tests were selected to assess a range of skills, including vocabulary, expressive and receptive language, immediate memory, and verbal association.

Boston Naming Test (Kaplan, Goodglass, & Weintraub, 1983) assessed word retrieval skills by requiring the child to produce correct verbal labels for 60 line drawings of common objects. Testing was begun with Item 1 and proceeded until a ceiling of six consecutive errors was reached.

Token Test (De Renzi & Faglioni, 1978) evaluated language comprehension using 20 colored tokens (of large and small circles and squares) to assess the child's ability to understand, remember, and carry out 36 simple commands (e.g., "Put the red circle on the green square").

Vocabulary is a subtest of the Wechsler Preschool and Primary Scale of Intelligence (WPPSI) (Wechsler, 1967), on which children were asked to provide definitions of common words.

Sentences is a WPPSI subtest designed to assess the ability to remember and repeat sentences of progressively increasing length.

Auditory Association is a subtest of the Illinois Test of Psycholinguistic Ability (ITPA) (Kirk, McCarthy, & Kirk, 1968) that requires the child to complete a series of verbal analogies (e.g., "Cotton is soft, stones are ____.").

Perceptual-Motor Measures

A set of perceptual-motor tests was selected to assess a variety of nonverbal abilities, including visual perception, visual-motor coordination, visuoconstructive skills, and immediate memory for visual information.

Developmental Test of Visual-Motor Integratin (VMI) (Beery, 1982). Visuospatial perception and visual-motor coordination were evaluated by having the child copy a series of geometric designs on the 15-item short form of the VMI.

Recognition-Discrimination is a subtest of the Florida Kindergarten Screening Battery (Satz & Fletcher, 1982) that assesses visual-perceptual scanning and matching skills. Children must match a geometric design to

one of four figures that is identical to the stimulus shape; the other three figures differ from the stimulus in orientation and/or specific detail.

Block Patterns is a subtest of the Hiskey-Nebraska Test of Learning Aptitude (Hiskey, 1957) that requires the child to construct a three-dimensional block design that matches a pictorial representation of the design.

Corsi Cubes (described in Milner, 1971) is a test of "spatial span" that assesses immediate memory for visual information. The test consists of nine blocks arranged randomly on a board, and the child must duplicate progressively longer block sequences that have been tapped out by the examiner. Two trials were given at each level (e.g., two 2-block sequences, followed by two 3-block sequences, etc.) similar to a digit span task.

Data Analysis

Data analysis focused on four primary behavioral outcomes: "internalizing" behavior problems, "externalizing" behavior problems, verbal deficits, and perceptual-motor deficits. Behavior problem scores were based on T-scores for the Internalizing and Externalizing scales of the Achenbach Child Behavior Profile (CBP). Verbal scores were obtained by combining standard scores (based on normal controls) on the five language measures: Boston Naming Test, Token Test, WPPSI Vocabulary, WPPSI Sentences, and ITPA Auditory Association. Perceptual-motor scores were obtained by combining standard scores on four measures: Beery VMI, Recognition-Discrimination, Block Patterns, and the Corsi Cubes Test.

Results

Correlations Among Behavioral, Cognitive, and Environmental Measures

Table 2 presents intercorrelations among behavioral measures and cognitive variables for both High Risk and Control children.

Insert Table 2 About Here

Correlations for the Control group are listed in the upper right half of the table, with correlations for the High Risk group in the lower left half. For both groups, Internalizing and Externalizing behavior problem scores were highly correlated, as were the scores on Verbal and Perceptual-Motor tests. There was also a trend toward an association between the behavioral and the cognitive measures, although this pattern was more evident in the High Risk group than in the Control group. For the High Risk children, correlations were also examined between the behavioral/cognitive variables and medical variables such as birthweight, head circumference, Apgar at one minute, and Apgar at five minutes; all of these correlations were low and nonsignificant.

Correlations between the HEQ scales and the psychological outcome measures are presented in Table 3. Environmental "press" for aggression

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Insert Table 3 About Here

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was significantly correlated with both Internalizing and Externalizing behavior problems for the control children, a finding that is consistent with the data of Laing and Sines (1982) and supports the view that

different behavioral adaptations can result from the same kind of environmental stress. In contrast to the findings for the controls, neither the Aggression-Home nor Aggression-Total scales were significantly related to behavior problems for the High Risk children. This raises the possibility that the adjustment problems shown by these children may be less strongly influenced by environmental factors (and by implication more influenced by biological factors) than is typical for normal children. Also of interest were the findings that the Academic-Intellectual scale of the HEQ was more consistently correlated with Verbal and Perceptual-Motor performance for the normal controls than for the High Risk children, but that the Academic-Intellectual scale was more strongly negatively correlated with behavior problems for the High Risk group than for the Controls. Parental education was significantly correlated with the Academic-Intellectual scale for both the High Risk (r = .76, p < .001) and Control (r = .54, p < .001) groups.

Regression Analyses of Environmental and Outcome Variables

Using the scores of the control children, separate multiple regression analyses were carried out for each of the four outcome measures (Internalizing behavior, Externalizing behavior, Verbal ability, and Perceptual-Motor ability), with the HEQ subscales as independent variables. For all analyses, the HEQ scores were highly correlated with the outcome measures; the multiple R was .53 for the HEQ scales with the Internalizing scale of the Achenbach CBP, .63 with the Externalizing scale, .55 with Verbal ability, and .54 with Perceptual-Motor ability. All of these correlations were statistically significant (p < .01) and accounted for 28% to 40% of the variance, depending on the specific analysis. The HEQ scales

of Aggression-Home, Aggression-External, and Affiliation had a major role in predicting behavior problems; the Academic-Intellectual, Achievement, and Sociability scales were particularly important in predicting cognitive abilities.

Classification of Behavioral and Cognitive Outcomes

For each of the four outcome variables, comparisons were made between a child's actual score and the predicted score (based on entering the environmental variables into the regression equation). Cut-offs for the difference between actual and predicted scores were established so that at least 90% of the control children did not exceed the cut-off levels[1]. The scores of the High Risk children were then entered into the regression equations, and they were placed in one of two groups depending on whether the actual-predicted difference score was higher or lower than the 90th percentile cut-off point for that particular outcome variable. Based on these procedures, 26% of the High Risk children had more Internalizing behavior problems than environmental conditions would predict, 37% had more Externalizing problems than predicted, 63% had significantly poorer verbal skills than predicted, and 37% had poorer perceptual-motor skills than predicted. Comparing these proportions to the 10% expected in the Control group for each outcome variable, the 26% for Internalizing behavior problems in the High Risk group only approached statistical significance ($z = 1.79$, $p = .07$); however, highly significant differences between proportions were found for Externalizing problems ($z = 2.73$, $p < .01$), verbal abilities ($z = 4.72$, $p < .001$), and perceptual-motor skills ($z = 2.73$, $p < .01$). These results clearly indicate that many of the High Risk

children experience significant behavioral and cognitive problems even when children with severe handicaps (i.e., cerebral palsy, mental retardation, blindness) have been excluded by prior screenings and when reasonable control has been exercised over conditions in the environment.

Relation of Medical Variables to Behavioral and Cognitive Outcomes

Since inclusion in the High Risk group due to neonatal medical complications resulted in behavioral outcomes of concern for substantial numbers of children, we attempted to further define the relation of specific perinatal risk factors to later outcomes. High risk inclusion criteria such as low birthweight, respiratory distress, asphyxia, and seizures were examined, as well as additional factors such as gestational age, head circumference, Apgar scores at one and five minutes, and maternal age. However, no single medical risk factor on its own discriminated between good and poor outcome groups, although there were trends toward smaller head size, lower birth weight, and increased respiratory distress in the cognitive deficit groups, as well as a greater frequency of resuscitation in the Externalizing group but lower gestational age and infrequent resuscitation in the Internalizing group. To combine the medical variables to maximize relationships with the cognitive and behavioral outcomes, a logistic regression (BMDP, Dixon, 1981) was carried out for each of the four outcome variables. This permitted combining both categorical and interval variables to predict outcome group membership, similar to a non-linear discriminant analysis. The presence of Internalizing behavior

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Insert Table 4 About Here

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problems (greater than environmental expectations) could be identified with 80% accuracy (but with a fairly large proportion of false positives) using Apgar scores and the absence of resuscitation as predictors. Externalizing group membership could be predicted with 100% accuracy through a combination of Apgar scores, maternal age, and length of hospital admission. Combinations of head circumference, Apgar scores, and maternal age classified verbal deficits with 86% accuracy, and combinations of gestational age, need for resuscitation, respiratory distress, and absence of hypoglycemia classified perceptual-motor deficits with 89% accuracy. Despite these high rates of predictive accuracy, these results must be viewed with caution since the logistic regressions may simply have capitalized on idiosyncratic patterns in this relatively small sample of high risk children.

Discussion

The results of this study indicate that children who have experienced major perinatal medical complications have significantly increased risks of developing learning or behavioral disorders, even when the influence of environmental factors has been reasonably well-controlled. This suggests that perinatal complications may result in some degree of CNS compromise for many children, even if it is not severe enough to produce more obvious handicaps such as mental retardation or cerebral palsy. Relating specific behavioral outcomes to perinatal factors was achieved with some success in the study, despite the relatively low frequency of any single perinatal event and the possibility that a particular behavioral outcome may result from multiple independent risk factors. Cross-validation with larger

samples of children should help to establish the degree of confidence that can be placed in these predictions, and these data will be obtained as this ongoing longitudinal study continues.

Studies that have attempted to evaluate environmental influences on behavior have had to resolve a number of conceptual problems, and the present study is no exception. Of particular importance are the issues of "genetic confounding" and "direction of effects" (see Sines & Zimmerman, 1981). To the extent that parents provide both the home environment and the genetic background for each child, it may be impossible to separate independent environmental effects from the effects of heredity on behavior. However, it is still possible to examine non-genetic organic risk factors as we have done for the high-risk children. With regard to the issue of "direction of effects," it can often be difficult to determine whether characteristics of the home environment (such as excessive discipline or social rejection) tend to produce behavior problems or are simply a response to a child's deviant behavior. Fortunately, considerable attention has been given to excluding items from the HEQ that may reflect a reaction to the child's behavior rather than a stable characteristic of the environment (Laing & Sines, 1982), but it is impossible to completely eliminate this problem.

The present study also raises important practical and theoretical questions about the process of identifying high incidence - low severity problems in children who have experienced a high risk birth. It would appear that the initial developmental screenings completed on these children at 4, 9, 18, and 30 months of age, utilizing the Denver Developmental Screening Test were not sufficiently sensitive to identify

many of those children who later displayed learning or behavioral problems, at least based upon our current measures. This outcome is not surprising given the general difficulty of early identification of milder learning problems. Harper and Wacker (1983) have previously noted that the major problem in screening efficiency for the DDST and other similar techniques with younger children (below age 4) is the high false negative rate. This means that children who are later identified as having cognitive delays have a higher probability of having been misclassified as normal initially and not referred for evaluation or assistance. Realistically, however, we cannot expect brief screenings to identify all types of problems at all levels of severity, and we must recognize that predicting low base rate or less severe developmental problems will be difficult with any screening procedure.

From a practical standpoint, it is crucial to decide what is the desired or intended outcome in providing a particular screening program and to adjust cutting scores and classification "hit rates" accordingly. Evaluation of the cost-benefit ratio of a screening procedure relates in part to the percentage of both underreferrals (false negatives) and over-referrals (false positives). If cost and availability of additional psychological evaluations or interventions are limited, a low false positive rate would be preferred. However, if the false negative rate becomes too high, children in need of assistance are deprived of help and the screening/referring agency loses credibility. Decisions on these issues can only be made by considering (a) the availability of resources for further evaluation and treatment, (b) the long-term impact of under-

identification of children who will not progress without special services, and (c) the implications of overidentification and the associated pejorative labeling of a child.

In addition to specific concerns about predictive accuracy, increasing our understanding of the complex relationship between early medical risk factors and the specific contributions of the psychosocial environment must remain a central concern for all predictive investigations in this field. Distinguishing "expected" from "unexpected" developmental disabilities has generally been ignored in previous follow-up studies, but the present investigation provides a methodology that should be applicable to other studies that seek to specify and adjust for the environmental "press" on a child's functioning. If we do not attempt to identify high risk children whose psychological problems deviate unexpectedly from environmental predictions, then we are unlikely to begin to understand how early medical risk factors relate to significant developmental disorders.

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Footnote

[1] So as not to compare the High Risk group (which had a restricted age range) to older normal controls, a subset of 38 younger control children between 58 and 65 months of age was selected for this phase of the analysis. This insured that the mean ages for the two groups did not differ by more than two months.

Table 1

Frequency of Perinatal Complications

Complication	Frequency[a]
Birthweight < 1500 grams	4
Respiratory Distress Syndrome	6
Asphyxia Neonatorum	8
Hypoglycemia	9
Seizures	2
Ventilatory Assistance	10
Other (e.g., SGA, Sepsis, Hyperbil.)	6

Mean Birthweight:	2811.08 grams
SD:	1005.99 grams
Range:	1040 - 4819 grams

[a] Seven children had multiple complications; therefore the number of complications exceeds the *n* of 35.

Table 2

Intercorrelations Among Measures of

Behavior Problems, Verbal Ability, and Perceptual-Motor Skills

	Internalizing	Externalizing	Verbal	Perceptual-Motor
Internalizing		72**	-21	-11
			(Control)	
Externalizing	66**		-15	-08
Verbal	-39*	-24		-46**
	(High Risk)			
Perceptual-Motor	-29	-22	62**	

* $p < .05$

** $p < .001$

Table 3

Correlations Between HEQ Scales and

Behavioral and Cognitive Outcome Measures

HEQ Scales	Internalizing	Externalizing	Verbal	Perceptual-Motor
Achievement	-19	-12	-05	-02
	-13	-08	14	20
Aggression (External)	43***	41***	-05	-05
	42**	33*	-20	-26
Aggression (Home)	31***	51***	-04	-08
	-08	-07	20	11
Aggression (Total)	45***	58***	-03	-05
	11	08	09	-02
Supervision	-03	03	05	27
	-13	-25	09	-18
Change	16	19	04	05
	26	39*	-12	-08
Affiliation	-09	-07	02	01
	11	-01	-16	-10
Parent Absence	21	25*	-14	-23
	22	43**	-20	-31
Sociability	-04	-01	-15	-17
	21	18	-29	-11
Academic-Intellectual	-19	-22	43***	36***
	-35*	-45**	21	38*

Note: Correlations for the High Risk group are in italics; the other correlations are for the Control group. Decimal points have been omitted.

* $p < .05$
** $p < .01$
*** $p < .001$

Table 4

Predicting Behavioral and Cognitive Problems

From Medical Risk Factors

	Predicted Problems	Predicted No Problems	% Correct (Hit Rate)
Internalizing Behaviors			
Problems	9	0	80%
No Problems	7	19	
Externalizing Behavior			
Problems	13	0	100%
No Problems	0	22	
Verbal Ability			
Problems	21	1	86%
No Problems	4	9	
Perceptual Motor Ability			
Problems	12	1	89%
No Problems	3	19	

Author Notes

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